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THE BATES LABORATORY ASPIRATOR

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INTRODUCTION

The Bates laboratory aspirator is a device designed for separating granular substances by means of a current of air which passes through the substances as they fall in a thin stream. It was developed primarily for use in connection with the laboratory analysis of rice and other grain and flaxseed and similar substances. It will assist rice and other grain inspectors and seed analysts in their work of inspection and grading of these commodities, for the use of the aspirator eliminates much of the work incident to the hand picking of rice and other grain and flaxseed samples. Without such a device the inspector must often resort to his lung power for removing from the samples the rice hulls or other lightweight particles of foreign material which can not be removed readily by means of sieves or other commonly used rice and other grain grading devices. In the grading of rough rice the aspirator provides a mechanical means for making complete separations of hulls from the rice kernels in a "shelling" of the rice. In the case of grading grain and flaxseed the intention has been to provide a machine to supplement rather than to displace existing grading apparatus.

A public patent (No. 1524012) for the aspirator has been granted to E. N. Bates by the United States Patent Office. This permits the manufacture and use of the patented article in the United States by any citizen of the United States without the payment of royalty.[1] (Fig. 1.)

[1] For a description of a different form of the aspirator for use as an attachment to a threshing separator for cleaning grain, rice, and other seeds at the time of threshing as a part of the threshing operation see Bates, E. N., Bodnar, G. P., and Baldwin, R. L., CLEANING GRAIN WITH THE BATES ASPIRATOR. U. S. Dept. Agr. Misc. Cir. 56, 21 p., 1926.

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PRINCIPLES OF SEPARATION BY AIR

In using air for separating granular substances the size, shape, and weight of the substances determine what may be accomplished in the

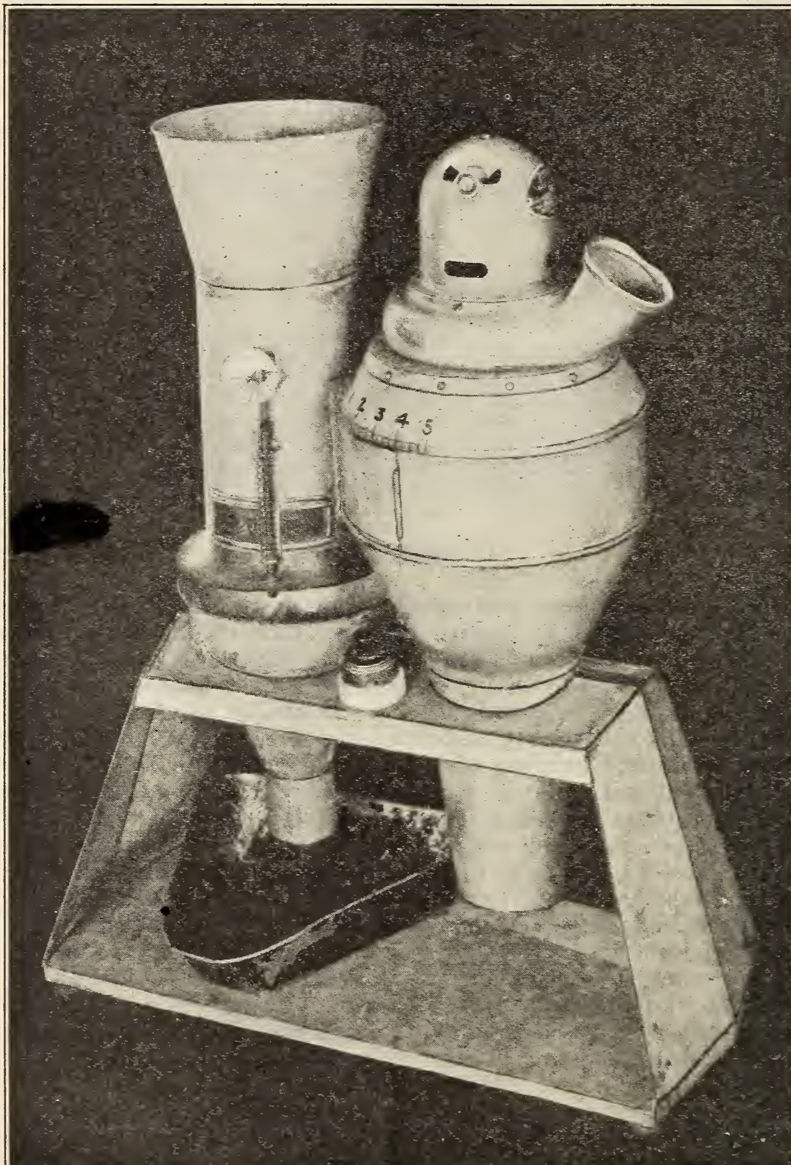

FIG. 1.—Bates laboratory aspirator

way of making separations. For example, particles of the same size and shape may be separated with respect to their weight by the use of the aspirator; again, particles of the same size and weight

may be separated on the basis of their shape; and third, particles of the same shape and weight may be separated on the basis of size by the use of the aspirator. In approaching the problem of separating granular substances by means of air it should be realized that although the theory of air separation appears simple there are practical difficulties which, to a degree at least, must be overcome.

The thoroughness of separation made possible by use of air depends to a large degree upon the rate of flow of the material into the air stream and the velocity of the air current. Because of the high fluidity and elasticity of gases it is very difficult to produce a current of air that will have a uniform velocity throughout the entire cross section of the air stream. Any solid substance that enters a stream of air offers resistance to it. Unless the particles to be separated by the air are evenly distributed throughout the entire cross section of the stream of air there will be a tendency for the air velocity to increase where the particles are the fewest and the resistance least and to be reduced in force of current in the parts where the particles are the most numerous. Such an unbalanced air current tends to result in poor separation. The necessity for a constant even feed of the substance being cleaned is therefore evident. In the aspirator described in this circular both the rate of feed and the air velocity can be controlled.

DESCRIPTION OF THE ASPIRATOR

The aspirator is usually made of galvanized sheet iron. It occupies a space approximately 22 by 10 inches and is 28 inches high. The total weight of the device, including the motor, is about 25 pounds.

The capacity or rate of cleaning of the aspirator varies with the quality, kinds, and combinations of the materials on which separations are made.

The aspirator is composed of the following parts: Receiving hopper, feed-control mechanism, aspirating chamber, hopper for receiving the discharged coarse material, connecting passage from aspirating chamber to cyclone, cyclone separator, flexible cup for holding the light material discharged from the cyclone, suction fan and motor, valve in the connecting passage for controlling the velocity of the air, and the mounting or support for the entire apparatus. (Figs. 1 and 2.)

The receiving hopper, which holds the material to be aspirated, has a volume of approximately 3 quarts dry measure, equivalent to about 5 pounds (2,268 grams) of wheat. The material to be aspirated flows into the aspirating chamber by gravity through an opening which is controlled by the feed valve at the lower end of the hopper.

The feed-control mechanism consists of a graduated eccentric dial, a J-shaped iron rod, a coiled spring, and a cone valve which also acts as a distributor for the material being aspirated. The adjustable part of the mechanism, the setting of which regulates the rate of flow of the material being aspirated, is conveniently mounted on the front of the outer cylinder which forms the receiving hopper and aspirating chamber. A small window for inspecting the rate of flow of material is also provided.

The funnel-shaped hopper, into which the aspirated material falls from the aspirating chamber, affords a means of collecting and direct-

ing this material into a receiving pan which must be placed under the outlet of the hopper before the feed valve is opened. On opposite sides of the cylindrical part of the hopper two sloping baffle plates are soldered, one above the other. The purpose of the baffles is to break the fall of the material and thus prevent spilling.

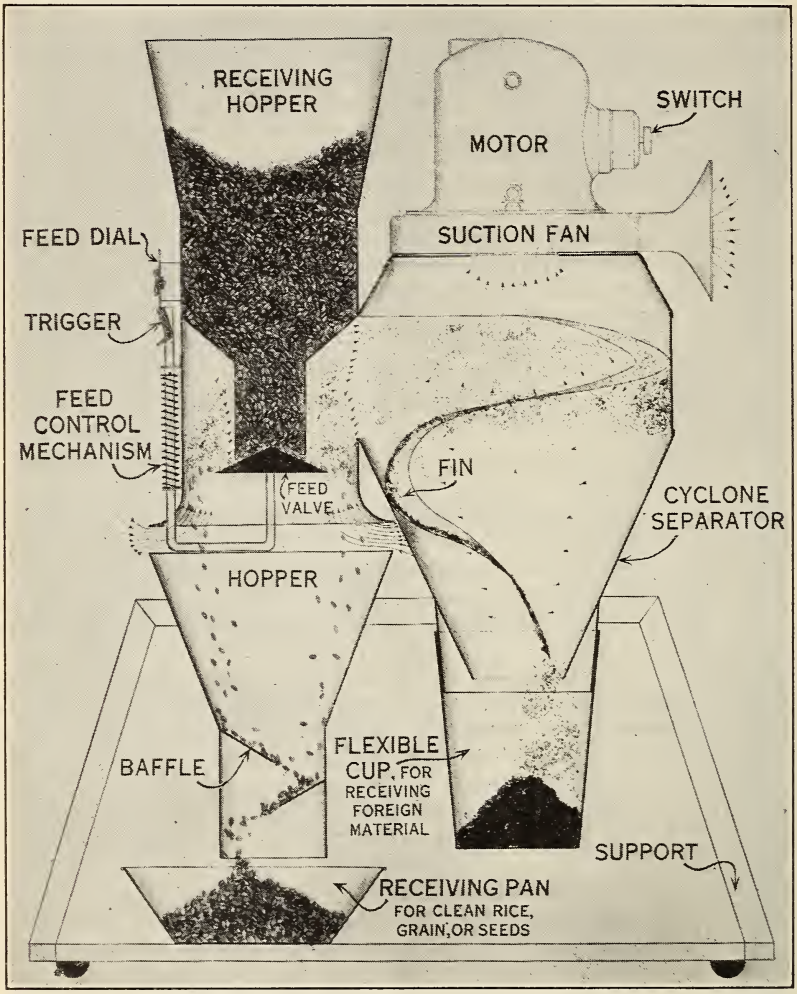

FIG. 2.—Cross section of aspirator, showing the path of the air and material as it passes through the device. The air-control valve can be seen in Figure 1

The lightweight particles, which are removed from the main stream of the material being aspirated, are carried by the air through a short connecting passage which directs the material into the cyclone at a tangent to the inside cylindrical part of cyclone.

The air-control valve is shaped to fit the outer surface of the cylindrical part of the cyclone, and slides around the cylinder, either opening or closing the air inlet to the cyclone, thus regulating the

velocity of the air that is applied to the material being aspirated. A scale of quarter inches drawn on the upper valve guide indicates the relative opening of the valve.

The function of the cyclone is to separate the solid particles from the air. This is accomplished by centrifugal force and the action of a spiral fin which directs the particles downward into the cup, the air passing upward and out through the fan.

A tapered flexible cup receives the lightweight solid material that has been separated from the air in the cyclone. A metal collar tapered to fit the inside of the top of the cup is permanently attached to the lower part of the cyclone. When the cup is pressed on firmly the connection is not only strong enough to hold the cup in position, but is practically air-tight.

The suction fan and motor unit used is of the small vertical-axis vacuum-sweeper type. Viewed from above, the fan rotates in a clockwise direction.

OPERATION OF THE ASPIRATOR

To operate the aspirator a weighed quantity of the rice, other grain, flaxseed or other material to be separated is placed in the receiving hopper with the feed valve closed. The air valve between the aspirating chamber and the cyclone is adjusted to give the proper suction and the motor is started. The feed valve is then opened enough to allow the material flowing over the cone-valve distributor to spread out over the entire surface of the cone in a thin sheet and flow over the circular edge of the base of the cone into the upward moving current of air. The controlled current of air, which is drawn through the aspirating chamber by the motor fan, rushes up through the thin sheet of material as it flows from the edge of the cone and carries with it the particles of material which are lighter in weight than the particles of material from which they are to be separated. The velocity of air required to do the most efficient work is obtained by adjusting the sliding air valve.

The rice, other grain, or flaxseed kernels, or any other materials which are too heavy to be lifted out by the air, drop into the discharge hopper where they collect and flow into the container which is placed beneath the opening of the discharge hopper.

The particles lifted out of the falling stream of material are carried with the air through the connecting passage into the cyclone collector. This material and the air enter the collector in a way which causes the air and solid particles to revolve rapidly inside the cyclone. The solid particles are thrown out against the inner surface of the cyclone collector upon which is attached a spiral fin. The action of the fin forces the rapidly revolving material downward through the lower outlet of the cyclone and into the cup below. The air, from which the particles of material have been separated, is drawn out of the cyclone by the fan.

When all of the material which was placed in the receiving hopper has passed through the device, the motor is stopped. The two portions into which the original sample has now been divided are ready for weighing or for further analyses.

MAKING ASPIRATOR ADJUSTMENTS

Because of the variation in the materials that can be separated, an adjustment suitable for one sample of material may not be the best adjustment for a succeeding sample. Experience gained in operating the aspirator soon teaches the operator the proper adjustment of the two valves for most efficient results. After the correct adjustment has been ascertained for any given kind of separation, these adjustments should be noted and thereafter should be used for similar separations. Experience with the aspirator indicates that in separations where the physical properties of the material to be removed approach the physical properties of the material being cleaned, slow feeding of the material being aspirated will give better results than fast feeding.

The adjustment of the feeding rate for any material is accomplished as follows: Start the fan with the feed valve closed. Loosen the feed dial by unscrewing the wing nut. Then start the feeding of the material, which is accomplished by turning the dial. Turning the dial causes it to engage with the top end of the trigger in the upper part of the J-shaped rod, and forces the rod downward. This opens the feed valve. When the feed valve has been opened sufficiently to permit a thin, even stream of the material to flow over the edges of the spreader cone, the dial should be locked in this position. The evenness of the flow is ascertained by observing the stream of material through the small window.

In operating the aspirator, it has been noticed that the very last of a sample to flow from the receiving hopper does not receive the same aspiration that the main part of the sample receives. This is due to the fact that the last flow from the receiving hopper is drawn into the aspirating chamber with a rush of air through the partially uncovered feed opening as the receiving hopper is emptied and this new air passage reduces the rate of air flow at the aspirating point. This means that small samples must be given a slightly different treatment than samples of normal size. In passing a small quantity of any material through the aspirator it has been found that the best results are obtained by dribbling the samples through the machine rather than by trying to feed it through with the feed mechanism. By dribbling is meant slowly pouring the material into the receiving hopper, thus allowing a small stream of material to flow into the air stream. If the pan from which the sample is being poured is allowed to rest on the edge of the receiving hopper during the pouring, the vibration of the machine produces an even and regular flow of material.

It is essential to handle the flexible cup with reasonable care because a dented or otherwise misshapen cup will prevent a good air seal for the lower end of the cyclone. Any leakage of air into the lower part of the cyclone is likely to cause an incomplete separation of the light material from the air with the result that some light material will appear in the fan discharge.

A clogging of the feed valve, caused by the accumulation of particles considerably larger than the average size of the material for which the valve was set, may be relieved by pressing down on the trigger arm. Upon being released, the valve returns immediately to its previous setting.

The feed valve can be closed instantly and completely, without disturbing the dial setting, by pressing upward on the trigger arm until the trigger disengages the dial.

APPLICATION OF ASPIRATOR TO RICE, OTHER GRAINS, AND OTHER SUBSTANCES

ROUGH RICE

The United States Department of Agriculture prescribes the aspirator as part of the standard laboratory equipment for grading rough rice.

In the grading of rough rice, a sample of the rice is put through the Smith shelling device to loosen the hulls from the kernels or it is rubbed by means of a hand rubbing block and corrugated board. Then it is passed through the Bates aspirator for the removal of the loose hulls. In this way an accurate determination can be made of the percentage of rice and hulls in a sample. Figure 3 shows rice hulls removed by the aspirator from shelled rice. By the use of the aspirator it is possible to make a separation of hulls and rice without the loss of the finely broken particles of rice. Many of the broken particles are lost when the hulls are " blown " from a rubbed portion.

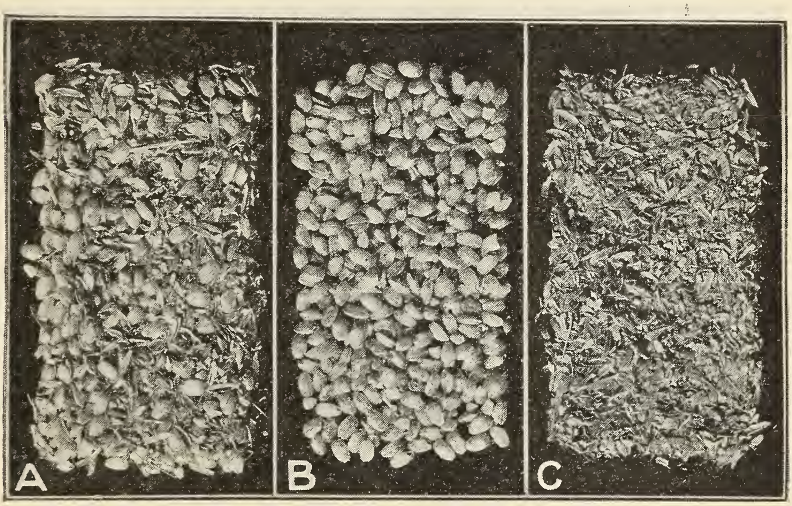

Fig. 3.—Rice cleaned by laboratory aspirator. A, rice as obtained from a Smith shelling device; B, same rice being cleaned by laboratory aspirator; C, type of material removed from rice

In the milling of rice the principal by-products are hulls and bran. The hulls are of little commercial value but are frequently used as fuel at the mill where they are produced. Rice bran is sold for stock feed at a price that approximates one-half that of finely broken rice. Consequently if any rice becomes mixed with either of these by-products a monetary loss is sustained. Any rice that goes into the hull stream is a total loss and any broken rice that goes into bran is sold as bran for about one-half its value as broken rice.

By first weighing the sample of hulls or bran and then weighing the rice which is reclaimed by the aspirator the amount of loss is

easily determined. Where the test shows the loss of rice to be significant the machinery can be immediately adjusted.

The aspirator is especially well adapted to removing immature and blighted rice kernels, some kinds of weed seeds, and other light foreign material from seed rice. These factors have a great influence on the value of rice for seed purposes, and the percentage of them in a sample is readily determined by means of the aspirator.

WHEAT

The aspirator may be applied to the grading of wheat in removing and classing as dockage the lightweight foreign material which is not removed from the samples by sieves or by any of the other devices commonly used for making the dockage determination. The material which can be removed by the aspirator usually consists of chaff, small

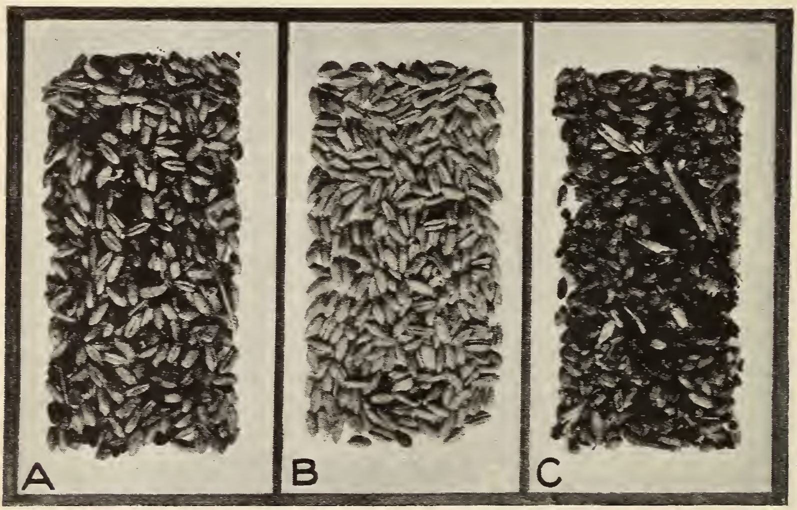

FIG. 4.—Wheat cleaned by laboratory aspirator. A, smutty wheat as received at market from LaMar, Wash.; B, same wheat after being cleaned by laboratory aspirator; C, type of material removed from the wheat, consisting mostly of smut balls and pieces of smut balls

pieces of straw and rachis, smut balls, pieces of smut balls, and smut spores. When left in the wheat sample, this material has a tendency to lower the grade of the wheat, because it reduces the test weight and because foreign material other than smut in dockage-free wheat is a grading factor. Figure 4 shows a sample of smutty wheat cleaned by use of the aspirator.

Although the aspirator has not as yet been approved as a supplemental device for determining dockage in connection with the grading of wheat, it will be useful in reducing the time and labor required to make a separation of foreign material other than dockage. In grading wheat, the factor "foreign material other than dockage" has in the past been determined by laboriously hand picking this material from a small, representative portion of the wheat sample. The aspirator not only reduces the labor but makes it possible to

increase the accuracy of a foreign-material determination by using a larger sample for analysis.

The following procedure is suggested when removing "foreign material other than dockage" from wheat samples: Aspirate the portion to be analyzed with a rather light suction, lifting out only the lightest materials. This portion is not likely to be entirely free of foreign material. Reaspirate the portion being analyzed, applying a strong suction and thus lifting out practically all of the remaining foreign material, together with some of the wheat. The portion of wheat so removed is relatively small and is easily hand picked, returning any wheat to the sample.

For a thorough cleaning of most samples of wheat grown on the Pacific coast the aspirator, when used in addition to the Emerson kicker and hand sieves, gives almost a complete separation of foreign material. The aspirator takes from the wheat those lightweight particles which, because of their size and shape, can not be separated from the wheat by means of sieves or the kicker.

As a test, the two machines, the aspirator and the kicker, were used separately and were then used together on a set of 21 samples of wheat grown on the Pacific coast, in which the total foreign material ranged from 1.5 to 24.1 per cent, and averaged 7.75 per cent. When used alone the aspirator removed an average of 82.4 per cent of the total foreign material from the samples; the Emerson kicker, when used alone on the same set of samples, removed an average of 80.3 per cent of the total foreign material.

The two machines, used in combination, removed an average of 97.7 per cent of the total foreign material regardless of whether the aspirator or kicker was used first in the operation.

When the two machines are used in combination it is often desirable to use the Emerson kicker first for removing such materials as long straws, seed pods, and thistle tops, for this allows the material to flow more evenly through the aspirator-feed opening.

OATS

When used in analyzing oat samples, the aspirator removes light foreign material, oat hulls, chaff, unfilled hulls, and many of the pin oats. It is often desirable to know what percentage of an oat sample consists of these light fibrous portions.

WHITE CLOVER SEED

Experiments have shown that the aspirator can be successfully used for cleaning white clover seed. A 30-pound sample of white clover seed which contained a considerable quantity of foreign material (consisting mostly of leaves and broken stems) was cleaned satisfactorily for commercial use by the aspirator. The owner of this seed stated that this aspiration of this seed added $1.50 to $2.50 per 100 pounds to its commercial value. The separation of the foreign material from the clover seed was easily made, because the clover seed was round and smooth compared with the foreign material which, for the most part, was light in weight and was rough and irregular in shape. Figure 5 shows a type of foreign material removed from a sample of white clover seed by the aspirator.

VETCH

On the Pacific coast, where vetch is frequently grown, it is usually threshed in a standard thresher which does not always clean the seed thoroughly. Vetch has a heavy round seed.

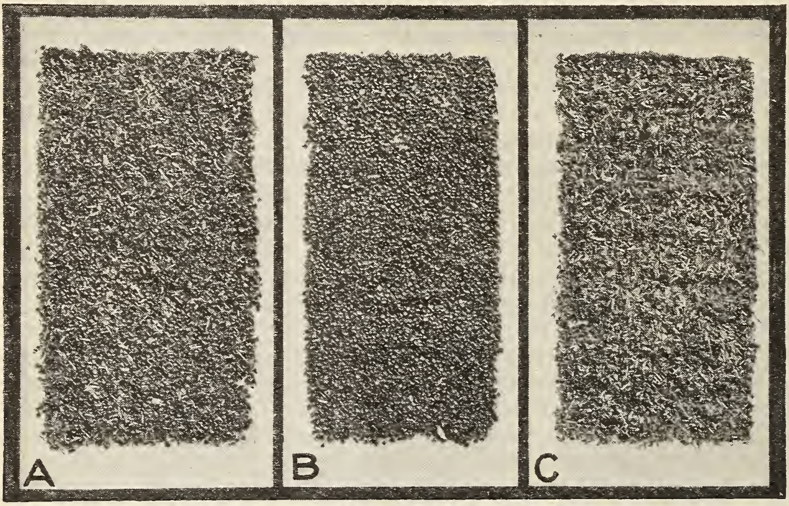

FIG. 5.—White clover seed cleaned by laboratory aspirator. A, white clover seed as received from a threshing machine in Crook County, Oreg.; B, same seed after cleaning by laboratory aspirator; C, type of material removed from white clover seed

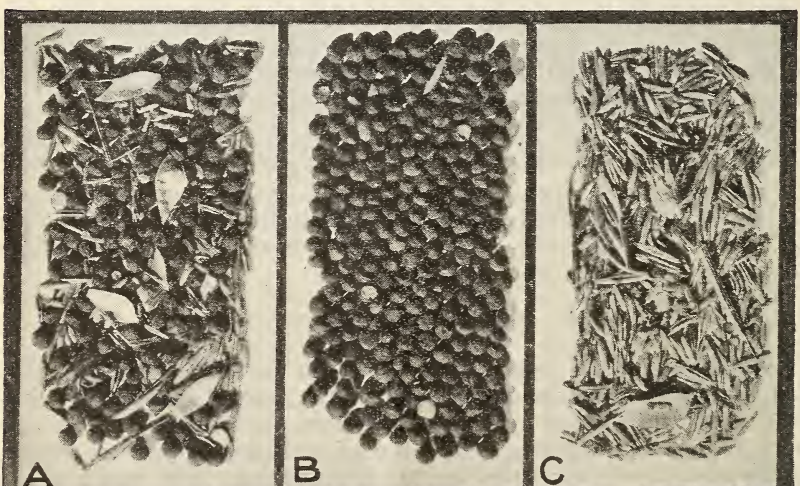

FIG. 6.—Vetch cleaned by laboratory aspirator. A, Oregon vetch containing a type of foreign material frequently found in vetch as threshed; B, same vetch after being cleaned by laboratory aspirator; C, type of material removed from vetch

Figure 6 shows results of a separation of foreign material from a sample of vetch grown in the Willamette Valley of Oregon. The foreign material consists principally of chess, thistle seeds, wild oats,

and broken vetch pods. The separation of these materials from the vetch seed is easily accomplished because of the extreme lightness of the foreign material compared with the vetch.

FLAXSEED

The aspirator can be of considerable assistance in analyzing flaxseed samples for determining the quantity of foreign material in the flaxseed, especially when the material consists of broken leaves, stems, and other light substances. Figure 7 shows results of a separation made by the aspirator on a sample of volunteer flaxseed grown at Vancouver, Wash.

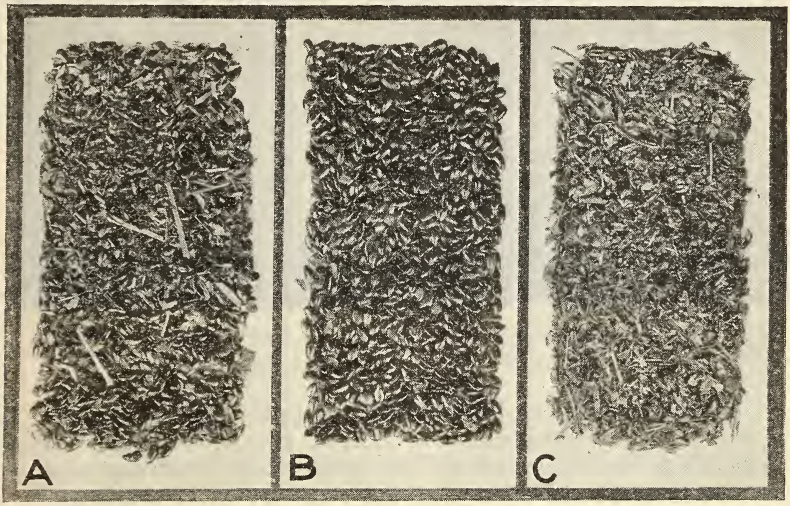

FIG. 7.—Flaxseed cleaned by laboratory aspirator. A, volunteer flaxseed grown at Vancouver, Wash.; B, same flaxseed after cleaning by laboratory aspirator; C, type of material removed from flaxseed

BARLEY

The completeness of separation of foreign material from barley by the aspirator depends to a large extent upon the quality of the barley and the character of the foreign material.

In Figure 8 is shown the result obtained by aspirating a sample of California barley which contained a type of material commonly found in barley. To obtain these results, it was found necessary to subject the sample to several treatments by the aspirator, corresponding to the sieving and resieving operations sometimes found necessary when using screens for determining the foreign material. The removal of foreign material of the type shown in the illustration is made rather easily when the barley is of a very good grade; that is, when it is plump and has a high-test weight.

CLEANING GRAIN FOR SEED BY LABORATORY ASPIRATOR

The laboratory-size aspirator was not designed for continuous operation as a grain cleaner, but for cleaning a few bushels of seed

grain even a laboratory-size aspirator can be used to advantage. When using the aspirator for cleaning seed, the receiving cup and cyclone should be allowed to become filled with foreign material. The cyclone collector then becomes inoperative and the foreign material is blown out through the fan. If the aspirator is located in a

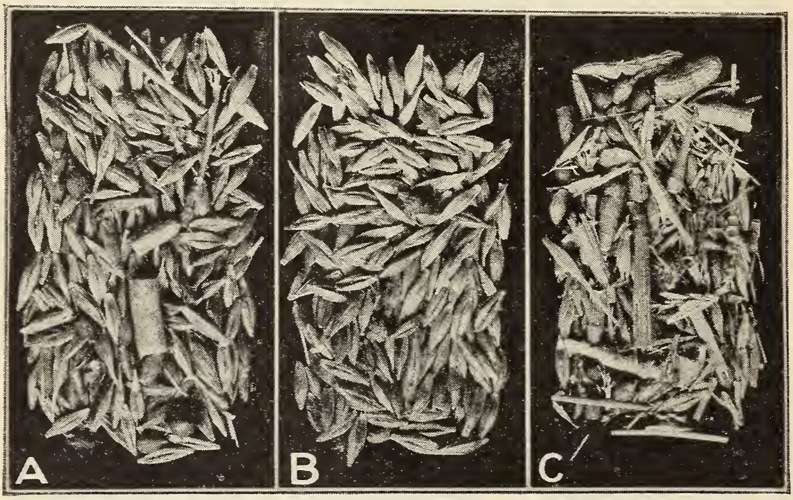

FIG. 8.—Barley cleaned by laboratory aspirator. A, California barley containing a type of foreign material found in threshed barley; B, same barley after cleaning with laboratory aspirator; C, type of material removed from barley

place where it is not feasible to blow the light material out into the air, when continuous operation is desired, provision should be made for the fan to discharge into a large porous bag or settling chamber. As a continuous cleaner, its average capacity is approximately 10 bushels of wheat per hour, and its time limit of operation would be that imposed by the motor installation.

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